Comparison of Energy-Efficient Routing Protocols in Mobile Ad-Hoc Networks

Shivani Dua
Department of Computer Science & Engineering
Amritsar College of Engineering & Technology
Amritsar, India
engg_shivani08@yahoo.com

Tanu Preet Singh
Research Scholar Student,
Uttarakhand Technical University,
Dehradun, India
tanupreet.singh@gmail.com

Prof. R.K Singh
Professor & OSD
Uttarakhand Technical University
Dehradun, India
rksinghkec12@rediffmail.com

Vivek Mahajan
Department of Computer Science & Engineering
Amritsar College of Engineering & Technology
Amritsar, India
vivek.mahajan@gmail.com

Abstract: **Mobile ad hoc network (MANET) is an autonomous system of mobile nodes connected by wireless links. It is a self organizing and self configuring network without the need of any centralized base station. In MANETs, the nodes are mobile and battery operated. Each node operates not only as an end system, but also as a router to forward packets [2]. The main aim of MANET is to build best routing algorithms that are adapted to randomly changing network topology [1]. In Few years, number of protocols has been developed and some comparisons are done on number of routing protocols like Ad hoc On-Demand Distance Vector Routing (AODV), Dynamic Source Routing (DSR). To the best of our knowledge, no published work is available in the literature, which compares as many criteria as we have done to evaluate the performance of the considered routing protocols [1]. This paper evaluates the performance of various ad hoc routing protocols such as DSDV, AODV, DSR, TORA and AOMDV in terms of energy efficiency and it also proposes a new routing algorithm that modifies AOMDV and it provides better performance compared to all the above lprotocols. Simulation is done using NS-2(version NS-2.34) [2].**

Keywords: **AODV, AOMDV, DSR, DSDV, TORA, MANET, Energy Efficient Routing.**

1. INTRODUCTION

Ad hoc network is a multi-hop wireless network, which consists of number of mobile nodes. These nodes generate traffic to be forwarded to some other nodes or a group of nodes. Ad hoc networking allows portable mobile devices to establish communication path without having any central infrastructure. Since there is no central infrastructure and the mobile devices are moving randomly, gives rise to various kinds of problems, such as routing and security. Routing is the process of selecting paths in a network along which to send network traffic. In packet switching networks, routing directs packet forwarding, the transit of logically addressed packets from their source toward their ultimate destination through intermediate nodes. An ad hoc routing protocol is a convention, or standard, that controls how nodes decide which way to route packets between computing devices in a mobile ad-hoc network [4]. A number of protocols have been developed for non-centralized networks, e.g. Temporally Order Routing

Algorithm (TORA) [1.] TORA is a protocol for multi-hop networks. The choice of a route in a multi-hop network influences the performance of the network, measured in terms of power consumption. There are some protocols that strive for energy efficient routing such as DSR (Dynamic Source Routing [2], AODV (Ad-Hoc On Demand Routing) [3] and DSDV (Destination-Sequenced Distance Vector)[4] These protocols offer varying degrees of efficiency. The main objective of this paper is to analyze the TORA protocol for efficiency in terms of power and suggest ways it could be improved. The main limitation of ad-hoc systems is the Availability of power. In addition to running the onboard electronics, power consumption is governed by the number of processes and overheads required to maintain connectivity [4]. The disadvantage of ad hoc network is that the nodes should be in range of a base, so that these nodes can receive the information and transmit it for further devices. If these nodes are not available, the whole network would fail [5].

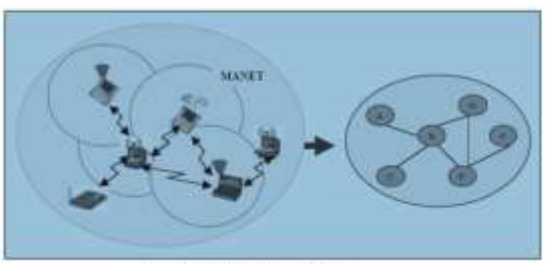

Figure 1.1 Mobile Ad Hoc Network

2. ROUTING PROTOCOLS IN MANETs

There are number of routing protocols for ad hoc networks, they are categorized into two: Proactive Routing and Reactive routing. Routing is the act of moving information from a source to a destination in an internetwork. Routing protocols use several metrics as a standard measurement to calculate the best path for routing the packets to its destination that could be number of hops, which are used by the routing algorithm to determine the optimal path for the packet to its destination[4][6]. Routing is mainly classified into static routing and dynamic routing. Static routing refers to the routing strategy being stated manually or statically, in the router. Static routing maintains a routing table usually written by a networks administrator. The routing table doesn‘t depend on the state of the network status, i.e., whether the destination is active or not [6]. Dynamic routing refers to the routing strategy that is being learnt by an interior or exterior routing protocol. This routing primarily depends on the state of the network i.e., the routing table is affected by the activeness of the destination. Table-driven routing protocols try to maintain consistent, up-to-date routing information from each node to every other node. Network nodes maintain one or many tables for routing information. Nodes respond to network topology changes by propagating route updates throughout the network to maintain a consistent network view. Source-initiated on-demand protocols create routes only when these routes are needed. The need is initiated by the source, as the name suggests. When a node requires a route to a destination, it initiates a route discovery process within the network. This process is completed once a route is found or all possible route permutations have been examined. After that there is a route maintenance procedure to keep up the valid routes and to remove the invalid routes[3] In this approach the associated routing protocols are again classified into three categories, based on the time at which the routes are discovered and updated.

1. Proactive Routing Protocol (Table Driven)
2. Reactive Routing Protocol (On-Demand)
3. Hybrid Routing Protocol.

2.1 Proactive (Table-Driven) Routing Protocols

In this family of protocols, nodes maintain one or more routing tables about nodes in the network. These routing protocols update the routing table information either periodically or in response to change in the network topology. The advantage of these protocols is that a source node does not need route-discovery procedures to find a route to a destination node. On the other hand the drawback of these protocols is that maintaining a consistent and up-to-date routing table requires substantial messaging overhead, which consumes bandwidth and power, and decreases throughput, especially in the case of a large number of high node mobility. There are various types of

Table Driven Protocols: Destination Sequenced Distance Vector routing (DSDV), Wireless routing protocol (WRP) [6], Fish eye State Routing protocol (FSR), Optimized Link State Routing protocol (OLSR), Cluster Gateway Switch Routing protocol (CGSR), Topology Dissemination Based on Reverse Path Forwarding (TBRPF)[7].

2.2 Reactive (On-Demand) Routing Protocols:

Reactive routing is also known as on-demand routing protocol these protocols have no routing information at the network nodes if there is no communication. These protocols take a lazy approach to routing [3]. They do not maintain or constantly update their route tables with the latest route topology. If a node wants to send a packet to another node then this protocol searches for the route and establishes the connection in order to transmit and receive the packet. There are various types of On-demand protocols are the dynamic source Routing (DSR), ad hoc on-demand distance vector routing (AODV).

2.3 *Hybrid Routing Protocols*

Hybrid protocols seek to combine the proactive and reactive approaches. An example of such a protocol is the Zone Routing Protocol (ZRP). ZRP divides the topology into zones and seek to utilize different routing protocols within and between the zones based on the weaknesses and strengths of these protocols. ZRP is totally modular, meaning that any routing protocol can be used within and between zones. The size of the zones is defined by a parameter r describing the radius in hops. Intra-zone routing is done by a proactive protocol since these protocols keep an up to date view of the zone topology, which results in no initial delay when communicating with nodes within the zone. Inter-zone routing is done by a reactive protocol. This eliminates the need for nodes to keep a proactive fresh state of the entire network [4].

3. DESCRIPTION OF SELECTED PROTOCOLS

3.1 *TORA*: The Temporally Ordered Routing Algorithm (TORA) is a highly adaptive, efficient and scalable distributed routing algorithm based on the concept of link reversal. TORA is proposed for highly dynamic, mobile, multi hop wireless networks. It is a source initiated routing protocol. It finds multiple routes from a source node to a destination node. The main feature of TORA is that the control messages are localized to a very small set of nodes near the occurrence of a topological change. To achieve this, the nodes maintain routing information about adjacent nodes. The protocol has three basic functions: Route creation, Route maintenance and Route erasure. TORA can suffer from unbounded worst-case convergence time for very stressful scenarios. TORA has a unique feature of maintaining multiple routes to the destination so that topological changes do not require any reaction at all. The protocol reacts only when all routes to the destination are lost. In the event of network partitions the protocol is able to detect the partition and erase all invalid routes [2].

3.2 Ad Hoc On Demand Distance Vector (AODV)

The Ad hoc On Demand Distance Vector (AODV) routing algorithm is a routing protocol designed for ad hoc mobile networks. AODV is capable of both unicast and multicast routing. It is an on demand algorithm, meaning that it builds routes between nodes only as desired by source nodes. It maintains these routes as long as they are needed by the sources. Additionally, AODV forms trees which connect multicast group members. The trees are composed of the group members and the nodes needed to connect the members. AODV uses sequence numbers to ensure the freshness of routes. It is loop-free, self-starting, and scales to large numbers of mobile nodes. The AODV protocol uses *route request* (RREQ) messages flooded through the network in order to discover the paths required by a source node. An inter-mediate node that receives a RREQ replies to it using a *route reply* message only if it has a route to the destination whose corresponding destination sequence number is greater or equal to the one contained in the RREQ. The RREQ also contains the most recent sequence number for the destination of which the source node is aware. A node receiving the RREQ may send a route reply (RREP) if it is either the destination or if it has a route to the destination with corresponding sequence number greater than or equal to that contained in the RREQ. If this is the case, it unicasts a RREP back to the source. Otherwise, it rebroadcasts the RREQ. Nodes keep track of the RREQ's source IP address and broadcast ID. If they receive a RREQ which they have already processed, they discard the RREQ and do not forward it. As the RREP propagates back to the source nodes set up forward pointers to the destination. Once the source node receives the RREP, it may begin to forward data packets to the destination. If the source later receives a RREP containing a greater sequence number or contains the same sequence number with a smaller hop count, it may update its routing information for that destination and begin using the better route. As long as the route remains active, it will continue to be maintained. A route is considered active as long as there are data packets periodically traveling from the source to the destination along that path. Once the source stops sending data packets, the links will time out and eventually be deleted from the intermediate node routing tables. If a link break occurs while the route is active, the node upstream of the break propagates a route error (RERR) message to the source node to inform it of the now unreachable destination(s).

3.3 *Dynamic Source Routing (DSR)*:

DSR is a routing protocol for wireless mesh networks and is based on a method known as *source routing*. It is similar to AODV in that it forms a route on-demand when a transmitting computer requests one. Except that each intermediate node that broadcasts a route request packet adds its own address identifier to a list carried in the packet. The destination node generates a route reply message that includes the list of addresses received in the route request and transmits it back along this path to the source. Route maintenance in DSR is accomplished through the confirmations that nodes generate when they can verify that the next node successfully received a packet. These confirmations can be link-layer acknowledgements, passive Acknowledgements or network-layer acknowledgements specified by the DSR protocol. However, it uses source routing instead of relying on the routing table at each intermediate device. When a node is not able to verify the successful reception of a packet it tries to retransmit it. When a finite number of retransmissions fail, the node generates a route error message that specifies the problematic link, transmitting it to the source node. When a node requires a route to a destination, which it doesn't have in its route cache, it broadcasts a *Route Request (RREQ)* message, which is flooded throughout the network. The first RREQ message is a broadcast query on neighbors without flooding. Each RREQ packet is uniquely identified by the *initiator's address* and the *request id*. A node processes a route request packet only if it has not already seen the packet and its address is not present in the route record of the packet. This minimizes the number of route requests propagated in the network. RREQ is replied by the destination node or an intermediate node, which knows the route, using the *Route Reply (RREP)* message. The return route for the RREP message may be one of the routes that exist in the route cache (if it exists) or a list reversal of the nodes in the RREQ packet if symmetrical routing is supported. In other cases the node may initiate it owns route discovery mechanism and piggyback the RREP packet onto it. Thus the route may be considered unidirectional or bidirectional. DSR doesn't enforce any use of periodic messages from the mobile hosts for maintenance of routes. Instead it uses two types of packets for route maintenance: Route Error (RERR) packets and ACKs. Whenever a node encounters fatal transmission errors so that the route becomes invalid, the source receives a RERR message. ACK packets are used to verify the correct operation of the route links. This also serves as a passive acknowledgement for the mobile node. DSR enables multiple routes to be learnt for a particular destination. DSR does not require any periodic update messages, thus avoiding wastage of bandwidth [8].

3.4 DSDV: *Destination Sequence Distance Vector (DSDV)* is a proactive routing protocol and is based on the distance vector algorithm. In proactive or table-driven routing protocols, each node continuously maintains up-to-date routes to every other node in the network. Routing information is periodically transmitted throughout the network in order to maintain routing table consistency. The routing table is updated at each node by finding the change in routing information about all the available destinations with the number of nodes to that particular destination. Also, to provide loop freedom DSDV uses sequence numbers, which is provided, by the destination node. In case, if a route has already existed before traffic arrives, transmission occurs without delay. However, for highly dynamic network topology, the proactive schemes require a significant amount of resources to keep routing information up-to-date and reliable. In case of failure of a route to the next node, the node immediately updates the sequence number and broadcasts the information to its neighbors. When a node receives routing information then it checks in its routing table. If it does not find such entry into the routing table then updates the routing table with routing information it has found. In case, if the node finds that it has already entry into its routing table then it compares the sequence number of the received information with the routing table entry and updates the information[2] [3].

4. MODIFIED AOMDV (ENERGY_ AOMDV):

The concept behind the modified protocol is to find the nodal residual energy of each route in the process of selecting path, select the path with minimum nodal residual energy and sort all the routes based on the descending order of nodal residual energy. Once a new route with greater nodal residual energy is emerging, it is again selected to forward rest of the data packets. It can improve the individual node's battery power utilization and hence prolong the entire network's lifetime[2].

The steps involved are:

1. Find the nodal residual energy of each route in the route discovery process.
2. Find the path with minimum nodal residual energy.
3. Sort out all the routes based on the descending value of nodal residual energy
4. Select the route with maximal nodal residual energy to forward the data packets.

5. RESULTS AND DISCUSSION

The Simulation is carried out in NS2 under LINUX platform. In this paper, different existing reactive routing protocols such as AODV, AOMDV, DSR and TORA are compared with the proactive routing protocol such as DSDV with respect to the performance parameters such as energy consumption, packet delivery ratio, packet lost, end to end delay and throughput. Also the most efficient protocol among the above 5 routing protocol is modified so that the new routing algorithm provides better performance than all the above existing routing protocols. The following table shows that the important parameters chosen for the NS2 simulation

Table 1. Simulation Parameters

Simulation Time	100s
Topology Size	1000m x 1500m
Number Of Nodes	50
MAC Type	MAC 802.11
Radio Propagation Model	Two Ray Model
Radio Propagation Range	250m
Pause Time	0s
Max Speed	4m/sec-24m/sec
Initial Energy	100J
Transmit Power	0.4W
Receive Power	0.3W
Traffic Type	CBR
CBR Rate	512 bytes x 6 per second
Number of Connections	[illegible]

:

Table 1. Simulation Parameters

6. SIMULATION PARAMETERS

1. Packet Delivery Ratio

It is the ratio of the data packets delivered to the destinations to those generated by the sources.

2. Energy consumption

This is the ratio of the average energy consumed in each node to total energy.

3. End to end delay

This is the ratio of the interval between the first and second packet to total packet delivery.

4. Throughput

The throughput metric measures how well the network can constantly provide data to the sink.

Throughput is the number of packet arriving at the sink per ms.

5. Number of Packets dropped

This is the number of data packets that are not successfully sent to the destination during the transmission. In this study the time versus number of packets dropped have been calculated.

6.1 *Simulation Results*

Figure 1 shows the Comparison of Energy consumption versus time for DSDV, DSR, TORA, AODV and AOMDV using 50 nodes. It shows that the energy consumption of networks using AOMDV is minimum compared to TORA, AODV, DSR and DSDV.TORA is consuming maximum energy. AODV is consuming lesser energy than TORA, DSR and DSDV.

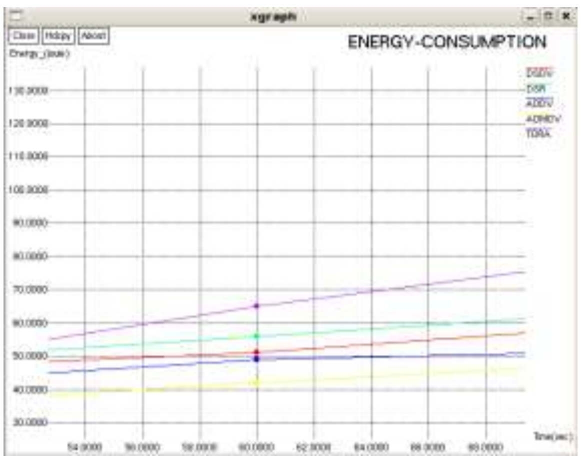

Fig 1. Comparison of Energy consumption versus time for DSDV, DSR, TORA, AODV and AOMDV using 50 Nodes

Figure 2 shows the comparison of Packet lost versus time for DSDV, DSR, TORA, AODV and AOMDV using 50 nodes. Packet loss is minimum using AODV compared to DSR and DSDV. It shows that the packet lost is minimum for AODV and AOMDV compared to the other 3 protocols

.

Fig 2. Comparison of Packet lost versus time for DSDV, DSR, TORA, AODV and AOMDV using 50 nodes

Figure 3 shows the comparison of Packet delivery ratio versus time for DSDV, DSR, TORA, AODV and AOMDV using 50 nodes. It shows that the packet delivery ratio of networks using AOMDV is better compared to AODV, TORA, DSR and DSDV.TORA has poor packet delivery ratio than all the other protocols.

Fig 3. Comparison of Packet delivery ratio versus time for DSDV, DSR, TORA, AODV and AOMDV using 50 nodes

Figure 4 shows the comparison of end to end delay versus time for DSDV, DSR, TORA, AODV and AOMDV using 50 nodes. It shows that the end to end delay is minimum using AOMDV compared to AODV, TORA, DSR and DSDV.TORA is having the highest end to end delay compared to all the other protocols.

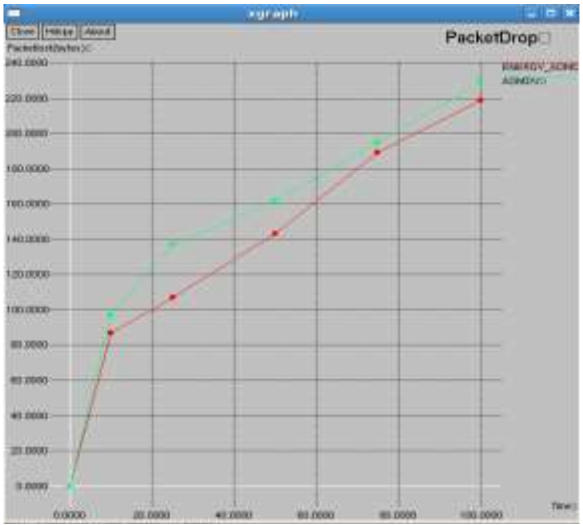

Fig 4. Comparison of End to end delay versus time for DSDV, DSR, TORA, AODV and AOMDV using 50 nodes

Figure 5 shows the comparison of packet lost for AOMDV and ENERGY_ AOMDV using 60 nodes. It shows that the packet lost is minimum for ENERGY_AOMDV compared to AOMDV.

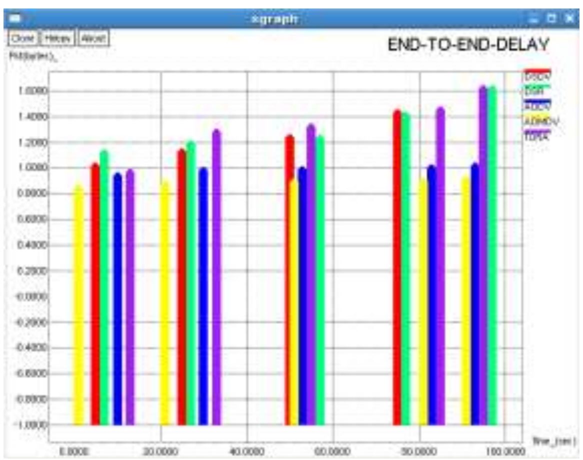

Fig 5. Comparison of packet lost for AOMDV and ENERGY_AOMDV using 60 nodes

Figure 6 shows the comparison of throughput for AOMDV and ENERGY_ AOMDV using 60 nodes. It shows that the throughput is maximum for ENERGY_AOMDV compared to AOMDV.

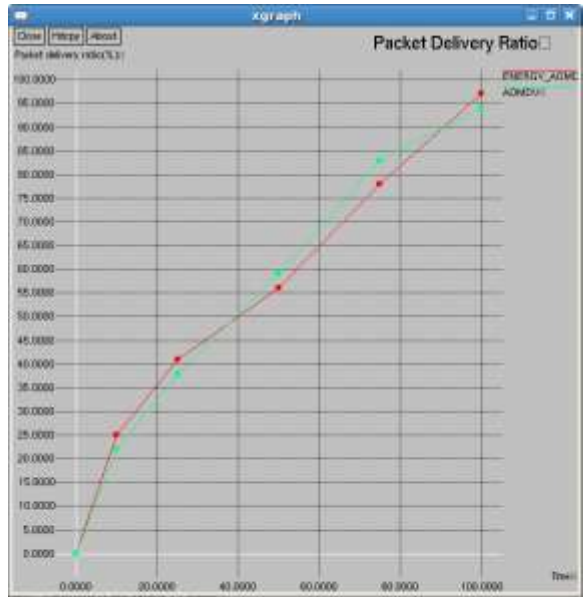

Fig 6. Comparison of throughput for AOMDV and ENERGY_AOMDV using 60 nodes

Figure 7 shows the comparison of packet delivery ratio for AOMDV and ENERGY_ AOMDV using 60 nodes. It shows that the packet delivery ratio is better for ENERGY_AOMDV compared to AOMDV.

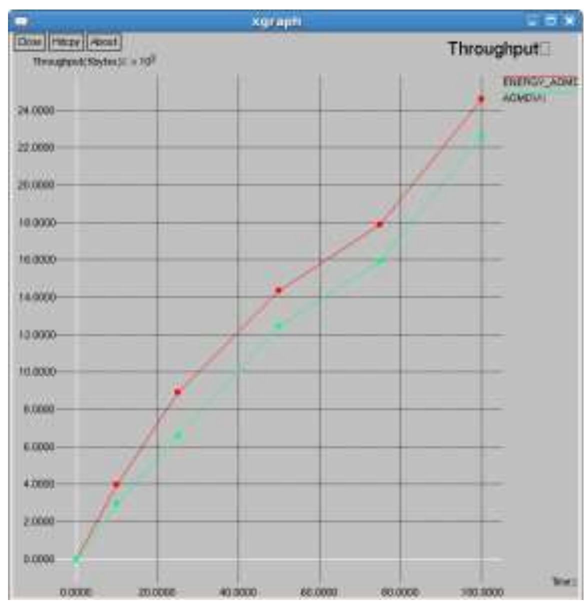

Fig 7. Comparison of packet delivery ratio for AOMDV and ENERGY_AOMDV using 60 nodes

Figure 8 shows the comparison of packet lost for AOMDV and ENERGY_ AOMDV using 60 nodes. It shows that the end to end delay is minimum for ENERGY_AOMDV compared to AOMDV.

Fig 8. Comparison of end to end delay for AOMDV and ENERGY_AOMDV using 60 nodes

Figure 9 shows the comparison of packet lost for AOMDV and ENERGY_ AOMDV using 60 nodes. The green colored line indicates AOMDV and the red colored line indicates ENERGY_AOMDV. It shows that the energy consumption is minimum for ENERGY _AOMDV compared to AOMDV.

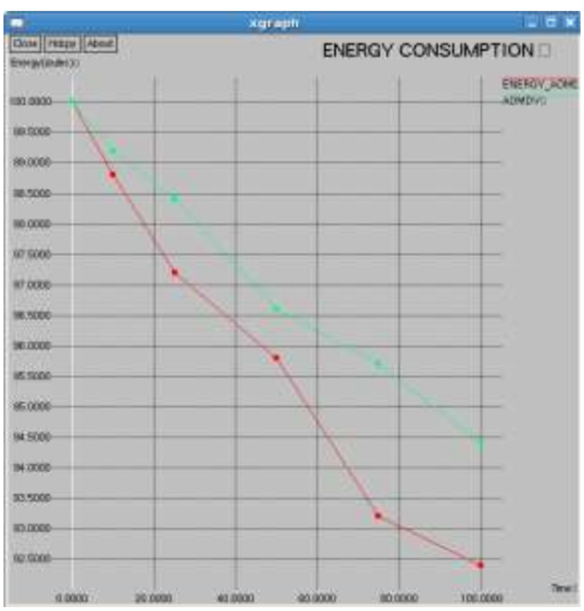

Fig 9. Comparison of energy consumption for AOMDV and ENERGY_AOMDV using 60 nodes

7. CONCLUSION

In this paper we have evaluated the performance of different existing routing protocols in MANET such as AOMDV, AODV, DSR, DSDV and TORA in different network environments. Results show that AOMDV consumes minimum energy compared to DSR, DSDV, TORA and AODV protocols. DSR seems to have slightly more balanced energy consumption between nodes. AOMDV is analyzed as the best protocol compared to AODV, DSR and DSDV when energy efficiency is taken into consideration. TORA exhibits poor performance among the above 5 routing protocols. It also proposed a new routing protocol MODIFIED_AOMDV in order to balance the traffic load among different nodes according to their nodal residual battery and prolong the individual node's lifetime and hence the entire system lifetime. Simulation results shows that the MODIFIED_AOMDV protocol is performing well compared to the existing routing protocols such as AOMDV, AODV, DSR, DSDV and TORA.

FUTURE WORK

This paper proposes further research into more efficient protocols or variants of existing protocols and network topologies that can improve the performance of MANETs. Emphasis is on protocols that could be suitable for the implementation of scalable system in high node density environments such as in manufacturing or product distribution industries. In the future, there is a scope to decrease ad hoc or sensor network's energy consumption by using MAC layer power-control techniques.

REFERENCES

[1]. Banerjee S, Misra A. Minimum Energy Paths for Reliable Communication in Multi- hop WirelessNetworks.

Proceedings of Annual Workshop on Mobile Ad Hoc Networking & Computing (MobiHOC 2002) 2002.

[2]. Jaya Jacob1, V. Seethalakshmi2 EFFICIENCY ENHANCEMENT OF ROUTING PROTOCOL IN MANET,MAY2012.

[3]. Petteri Kuosmanen, Finnish Defence Forces Naval Academy Classification of Ad Hoc Routing Protocols,2009

[4]. Kapang Lego, Pranav Kumar, Dipankar Sutradhar Comparative Study of Adhoc Routing Protocol AODV, DSR and DSDV in Mobile Ad hoc Network, 2001

[5]. Anne Aaron, JieWeng, Performance Comparison of Ad-hoc Routing Protocols for Networks with Node Energy Constraints International Journal of engineering and technology, EE 360 Class Project Spring 2000-2001

[6]. Perkins C. Ad Hoc Networking: Addison-Wesley: 2001; 1-28.

[7]. V. Kanakaris, D. Ndzi and D. Azzi Ad-hoc Networks Energy Consumption: A review of the Ad-Hoc Routing Protocols Journal of Engineering Science and Technology Review 3 162-167, 2010.

[8] V.Ramesh , Dr.P.Subbaiah , N. KoteswarRao , M.JanardhanaRaju , Performance Comparison and Analysis of DSDV and AODV for MANET International Journal on Computer Science and Engineer-ing Vol. 02, No. 02, 183-188 , 2010.

[9] Md. Shohidul Islam, Md. Naim Hider , Md.TouhidulHaque, LetonmiahAn Extensive Comparison among DSDV, DSR and AODV Protocols in MANET International Journal of Computer Applications (0975 – 8887) Volume 15– No.2, February 2011.

[10] Anuj K. Gupta, Member, IACSIT, Dr. Harsh Sadawarti, Dr. Anil K. Verma Performance analysis of AODV, DSR Routing Protocols International Journal of Engineering and Technology, Vol.2, No.2, ISSN: 1793-8236226, April 2010

[11] Sunil Taneja and Ashwani Kush, A Survey of Routing Protocols in Mobile Ad Hoc Networks International Journal of Innovation, Management and Technology, Vol. 1, No. 3, ISSN: 2010-0248, August 2010.

[12] Rajeshwar Singh, Dharmendra K Singh Performance Evaluation of DSR and DSDV Routing Protocols for Wireless Ad Hoc Networks Int. J. Advanced Networking and Applications 732 Volume: 02, Issue: 04, Pages: 732-737 , 2011.

[13] Marco Fotino, Antonio Gozzi Floriano De Rango, Salvatore Marano, Juan Carlos Cano, Carlos Calafate Pietro Manzoni, “Evaluating Energy-aware Behavior of Proactive and Reactive Routing Protocols for Mobile Ad Hoc Networks.

[14]. Dhiraj Nitnaware1 & Ajay Verma, “Performance Evaluation of Energy Consumption of Reactive Protocols under Self-Similar Traffic”, International Journal of computer science and communication vol.1, No.1, January-June 2010.

[15]. Yumei Liu, Lili Guo, Huizhu Ma, Tao Jiang, Energy Efficient on–demand Multipath Routing Protocol for Multi-hop Ad Hoc Networks

[16]. S. Giannoulis, C. Antonopoulos, E. Topalis, S. Koubias, ZRP versus DSR and TORA: A comprehensive survey on ZRP Performance, IEEE Transactions on Industrial Informatics Vol. 3, No. 1, pp. 63-72 (Feb. 2007)